Space Weather Technical Forecast

Issued on Monday 16 December 2024 at 01:29 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Isolated R1/R2 Radio Blackouts likely at times.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity has increased to Moderate levels following an impulsive M3.1 flare at 15/2024 UTC from AR3920. There are currently seven sunspot regions on the Earth-facing disc. Most complex of these is AR3917 (Dkc/Beta-Gamma) in the far southwest disc, with occasional C-class flaring. The region is approaching the western horizon and so increasingly difficult to analyse in available imagery. Growth was observed in AR3924 (Esi/Beta-Gamma) with proliferation of minor spots in its trailing portion. AR3920 (Csi/Beta-Gamma) decreased in overall size, but developed some small, mixed polarity spots in its leading region. Other regions on the disc were largely unchanged in appearance, although a small, unnumbered region emerged in the far southwest.

A filament eruption was observed around 15/0400 UTC from a region to the southeast of AR3924. Some coronal dimming was evident in GOES SUVI-195 imagery and a faint 'partial halo' CME was indicated in STEREO A COR 2 imagery and to a lesser degree in LASCO C2/C3 imagery. This CME is awaiting modelling, but there is likely an Earth-directed component from this feature.

Solar Wind / Geomagnetic Activity: Solar winds, as reported by ACE at L1, indicated the onset of a high-speed stream from a coronal hole, the anticipated CH99/+. Solar wind speeds increased from background levels to become slightly elevated from around 15/0800 UTC, thereafter varying largely between 400-450km/s. Density was generally around average, but became below average for a time following the onset of the high-speed stream around 15/0800 UTC. The Interplanetary Magnetic Field (IMF), Bt, was moderate at first, before becoming weak between 15/1300-2100 UTC, after which it became moderate again. The north-south component, Bz, oscillated between positive and negative, but generally favoured a weakly negative direction, though became moderate at times. Over the whole period it varied between +7/-10nT. The phi angle was positive (away from the Sun). The net result of the above solar wind measures was for Quiet to Unsettled geomagnetic activity (Kp2-3).

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at background levels. High energy electron flux (greater than 2MeV) observed by GOES16 was mainly background. The associated 24-hour fluence was below Active, on a declining, then largely steady trend. The 16/0000 UTC observation was 1.16e6 integrated pfu.

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Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate Solar activity is expected with M-flares considered likely on Days 1 and 4 (16 and 19 Dec) and with a chance of M-flares on Days 2 and 3 (17 and 18 Dec). There is a slight chance of isolated X-class flares throughout.

Solar Wind / Geomagnetic Activity: At least one, perhaps two CMEs have the potential to arrive at Earth between Days 2 and 3 (17 and 18 Dec). A declining connection to the high-speed stream of CH99 is expected to see solar wind speeds ease from slightly elevated to slow-ambient levels between Days 1 and 2 (16 and 17 Dec), with no further coronal hole enhancements expected during the period.

Geomagnetic activity is expected to be mainly Quiet to Unsettled, with a slight chance of isolated Active intervals between Days 1-3 (17-19 Dec). This forecast is likely to be updated in subsequent forecasts, especially for Days 2 and 3 (17 and 18 Dec) pending further analysis of recent CME activity.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at background, but with a daily slight chance of rising in response to any notable flares. High energy electron flux is expected to be at background to moderate levels. The 24-hour fluence is expected to remain below the Active threshold.

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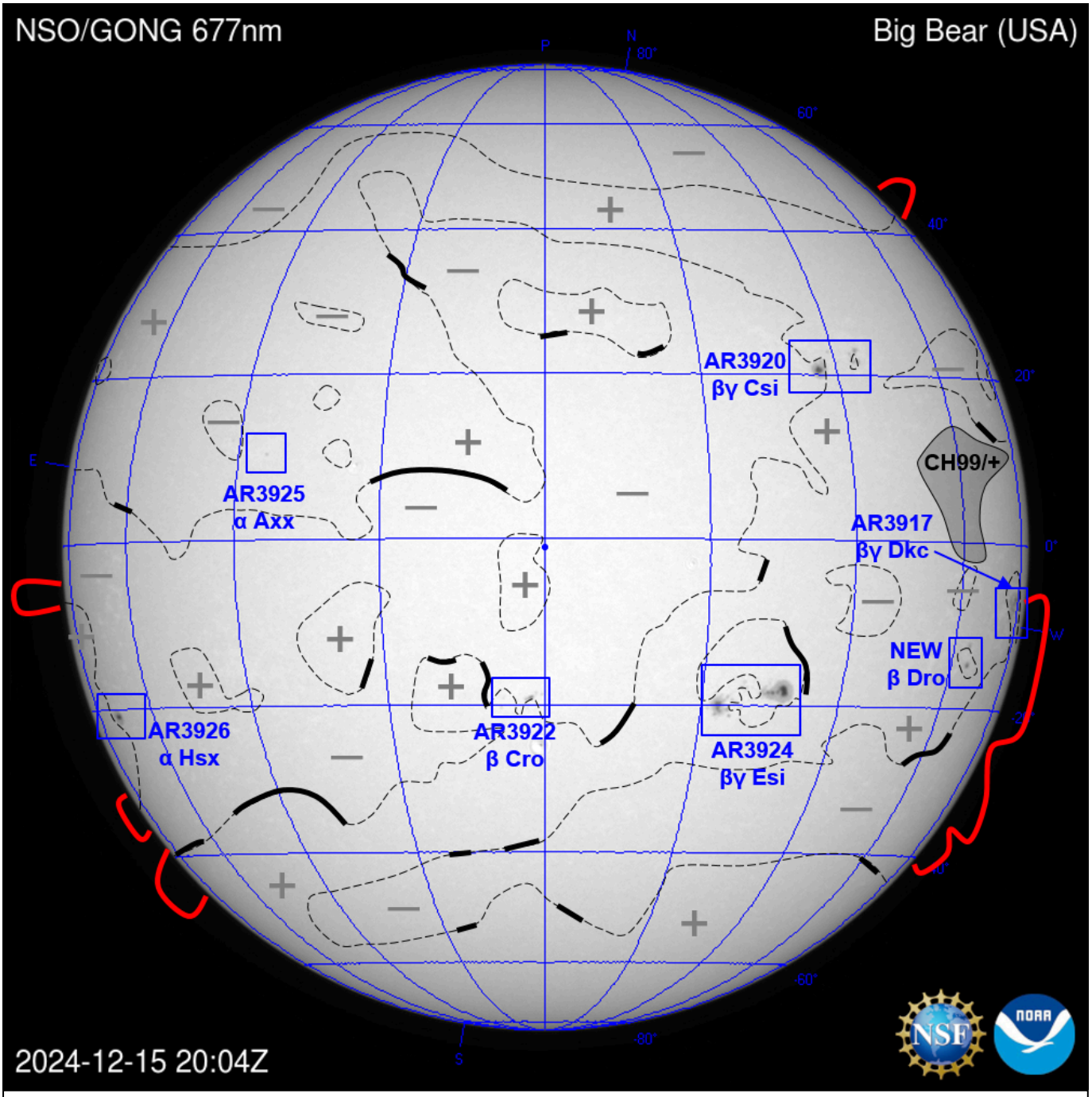
Figure 1: MOSWOC Solar Synoptic Map valid 15/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A CME associated with a large filament eruption in the southwest of the disc late 14 Dec is expected to pass mostly ahead and below Earth's orbit, although there is a slight chance it may give a glancing blow to Earth late Day 2 (17 Dec) or early Day 3 (18 Dec). Potentially more significant is a further filament eruption around 15/0400 UTC from a region to the southeast of AR3924. Some coronal dimming was evident in GOES SUVI-195 imagery and a faint 'partial halo' CME was indicated in STEREO A COR 2 imagery and to a lesser degree in LASCO C2/C3 imagery. This CME is awaiting modelling, but there is likely an Earth-directed component from this feature. Forecast Geomagnetic Storm probabilities do not currently include consideration to this second CME and will be updated once modelling is completed.

The coronal hole-based forecast carries much higher confidence. Earth is currently within the high-speed stream of CH99/+, with slightly elevated wind speeds that appear to have peaked around 450km/s. A gradual decline of this enhancement is expected through Days 1 and 2 (16 and 17 Dec) with speeds returning to slow-ambient levels. No further coronal hole enhancements are anticipated through the remainder of the forecast period. MOSWOC ENLIL output is too slow to ease the high-speed stream from CH99/+. Furthermore, a stronger enhancement between Days 2-4 (17-19 Dec) has no observable source region currently on the visible disc. This is consequently considered anomalous and disregarded at this stage.

Geomagnetic activity is expected to be mainly Quiet to Unsettled, with a slight chance of isolated Active intervals between Days 1-3 (17-19 Dec). This forecast is likely to be updated in subsequent forecasts, especially for Days 2 and 3 (17 and 18 Dec) pending further analysis of the 15 Dec CME event.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Radio Blackouts - X-Ray Flares

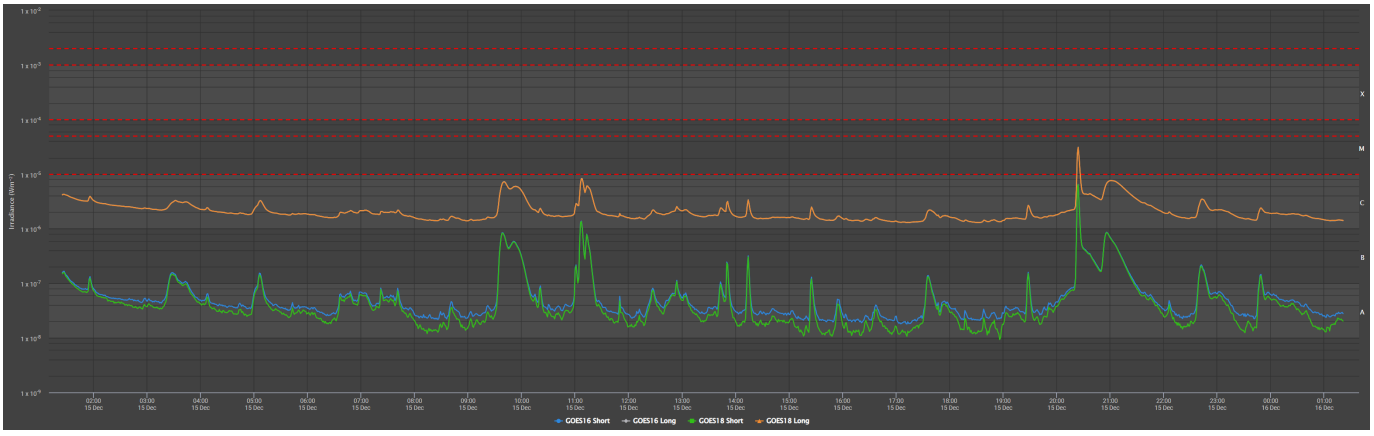
Solar Activity has increased to Moderate levels following an impulsive M3.1 flare at 15/2024 UTC from AR3920. There are currently seven sunspot regions on the Earth-facing disc. AR3917 (Dkc/Beta-Gamma) is approaching the southwestern limb and as such any detail is becoming increasingly difficult to discern as it rotates out of view, but it remains somewhat active with occasional C-class flare activity. AR3924 (Esi/Beta-Gamma), in the southwest disc, is the next most complex region and consists of a mature leading region and a smaller, irregularly shaped main trailing region with proliferation of numerous small spots surrounding it. AR3920 (Csi/Beta-Gamma) provided the most recent M-class flare, with evidence of small spots of mixed polarity in its leading region. The remaining regions on the disc are smaller and more magnetically simple.

Regarding the evolution of sunspot regions in the four days, AR3917 will cross the western solar horizon at the end of Day 1 (16 Dec). There continues to be the likelihood for further regions to rotate onto the disc from over the east limb between Days 2-4 (17-19 Dec) corresponding to Ex-AR3902, Ex-AR3905 and Ex-AR3906. The latter two produced M-class flares when they were last on the facing-disc and recent far-sided CME activity and helio-seismic soundings suggest that at least one of these regions remains active.

Overall Low to Moderate Solar activity is expected to be maintained, with M-flares considered likely on Days 1 and 4 (16 and 19 Dec) and with a chance of M-flares on Days 2 and 3 (17 and 18 Dec). There is a slight chance of isolated X-class flares throughout.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	60	40	50	60
Very Active	R3-R5 (X Class)	No	10	5	5	10

Figure 2: Latest GOES16/18 X-Ray Flux



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Solar Radiation Storms (High Energy Protons)

GOES18 proton flux carries a daily slight chance of reaching S1/Minor Storm levels or greater from any significant solar flares. Proton enhancements are most likely from AR3917, but the region will rotate over the western horizon by Day 2 (17 Dec), with risks reducing slightly later in the period pending developments of the other sunspot regions currently on the facing-disc.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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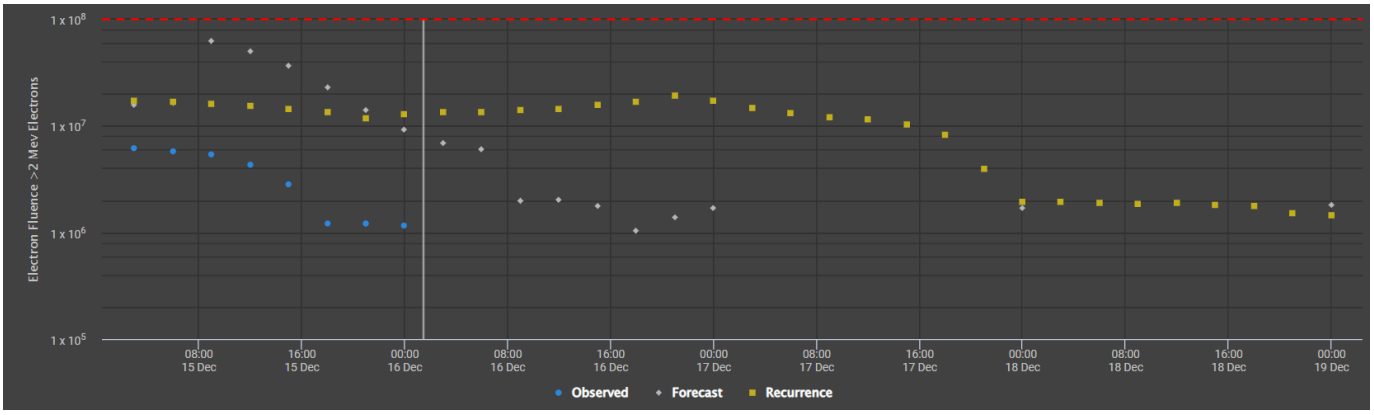
High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has varied between background and diurnally moderate levels. Observed flux has dropped out as a consequence of the increased solar wind pressure from CH99/+. Electron flux may recover back to more persistently moderate levels for a time between Days 2 and 3 (16 and 17 Dec), before likely reverting to background levels again on Day 3 (18 Dec) due to anticipated CME influence.

The associated 24-hour fluence is well below the Active (1e8 integrated flux) threshold, on a steady trend and expected to remain below this level throughout the forecast period.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 3: MOSWOC REFM forecast and Recurrence. REFM is currently giving good guidance.



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